

BELLCOMM, INC.

SUBJECT: Orbital Inclination Requirements:
Applications A Mission
Case 227

DATE: February 9, 1967
FROM: W.W. Elam

ABSTRACT

The goals of the Applications A experiment package concern meteorology and earth resources. The effects of orbital inclination upon the goals of the Applications A experiment package, which concern meteorology and earth resources, are discussed. An inclination $> 50^\circ$ has been requested. Because of the distributions of global weather systems and of Earth test sites, the expected scientific return from this mission would be seriously degraded by a low (28.5°) inclination orbit. Compromise inclinations (40°) may be possible for launch near the northern hemisphere winter solstice.

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MEMORANDUM FOR FILE

Introduction

As detailed mission planning for Applications Mission A is actively undertaken it is important that realistic requirements for orbital inclination be stated. This memorandum explains why a high orbital inclination is essential if good data are to be obtained. Although only the Application A Mission is discussed, similar remarks and conclusions will be pertinent for any multi-instrument application mission whose objective is to observe the Earth or its atmosphere.

Experiments

On the attached sheets the 16 Applications Mission A experiments are tabulated. The objectives of each experiment are briefly stated. The orbital inclination requirements (stated or implied) are noted. Remarks are made on each experiment relating orbital inclination to achievement of objectives. A summary of these inclination requirements is given here by the NASA experiment number.

Strong Requirement for High Inclination Orbit	High Inclination Orbit Desirable	Low Inclination (28.5°) Orbit Satisfactory
High ($>50^\circ$) Inclination		

S-041	S-046	S-039	S-039
S-042	S-047	S-040	S-040
S-043	S-048		
S-044A	S-049		
S-044B	S-050		
S-044C	S-057		
S-045	S-060		

These experiments should be considered not only as individual experiments, but also in a much more important sense as an experiment package designed to make a significant contribution to meeting important national meteorological and resources program goals. It is meaningful to think of the effect of orbital inclination on the mission as related to its program goals. Thus a listing of minimum orbital inclinations acceptable to each principal investigator is not a sufficient or realistic basis upon which to judge the effect of different orbital inclinations.

Atmospheric Sensing

Many of the experiments (S-043, S-044B, S-045, S-044A S-047, S-049, S-050, S-060) are directed toward the goal of globally measuring the vertical profile of the state parameters and variable constituents of the atmosphere. The development of such techniques is essential to significant progress in meteorology and weather forecasting. The flight of a large number of candidate instruments on Application A will allow comparison of the merits of these instruments in a short time relative to that which would be required by other instrument platforms. These experiments can be very important in the development of technology required by the World Weather Watch and the associated Global Atmospheric Research Program.

To illustrate the effect of orbital inclination on the return from this group of experiments consider atmospheric temperature which is a fundamental parameter. Vertical temperature profiles have relatively little temporal or spatial variation in the tropics. In Figure 1 it is seen that typical summer and winter temperature profiles for Cape Kennedy are almost identical, and very similar profiles are found all around the world in the tropics. Poleward of this latitude the seasonal and intraseasonal variations become markedly greater. Shown in Figure 2 are 3 typical vertical temperature profiles for a station at 64° latitude. There are marked differences between summer and winter and also between the two winter profiles separated by only 8 days. The differences between these and the Cape Kennedy profiles are obvious. For a 28.5° orbit, only the first type of profile, Fig. 1, will be sensed continually. For a high inclination orbit, profiles sensed will vary continually from the first type to the second, Figure 2, and back again.

Finding the desired variations of vertical temperature profiles is, then, a function of latitude and season. At the winter solstice (in northern hemisphere) a reasonably useful range could be found at 40° latitude in a two week mission; at the autumnal equinox at 55° latitude.

To fully test the ability of these Applications A instruments to sense vertical temperature profiles as many types and variations as possible should be sensed. They should be sensed over different types of underlying surfaces in order to allow for the differing effects of background radiation. It is clear that if the Applications A mission is flown at a 28.5° orbital inclination which permits sensing only the relatively invariant vertical temperature profiles of the tropics comparatively little can be accomplished toward fully demonstrating the capabilities of the instruments.

If these instruments are exercised together in a high ($> 50^\circ$) orbit, attended by man, sensing so far as possible the complete range of variations of the parameters to be measured, reliable data as to the merits of each instrument compared to the others and to ground based standards can be obtained in a matter of days. The best sources of conventional data are the radiosonde and meteorological rocket sounding networks in the United States and Canada.

Resources

The multispectral photography experiment, S-042, has a very large data return capability. The objective of this experiment is to apply multispectral photographic techniques to a wide range of Earth science/applications problems. It is essential that a wide variety of documented "ground truth" areas be overflown. Although there are some 75 of these sites the following are considered to be the principal ones in the Earth Resources Program supporting this experiment:

	<u>Latitude</u>		<u>Latitude</u>
Lafayette, Indiana Area	38°	New York City Area	42°
Western Kansas	38°	South Cascade Glacier Area	48°
Davis, Cal. Area	38°	Carlin, Nevada Area	38°
Oregon and Wash. Area	45°	Pisgah Crater, California	36°
Weslaco, Texas Area	26°	Salton Sea, Calif. Area	36°
San Pablo Reservoir, Cal Area	40°	Delaware River Area	38°
Phoenix, Arizona Area	34°	Point Barrow, Alaska Area	71°
Michigan	43°	Goose Bay, Labrador Area	54°

Since only one of these ground truth areas, that of Weslaco, Texas, falls below 28.5° , all the others will be missed. Furthermore, the experiment is designed (and is capable of returning enough data) to cover extensive northern and southern areas of the world having economic and scientific importance. This function will also be seriously curtailed by a 28.5° inclination. A forty degree orbit would overfly roughly half of these sites, a fifty degree orbit all but two.

Discussion and Conclusions

It is clear that the usefulness of the Applications A payload will be very seriously degraded if the package is flown in a 28.5° orbit, and that the request by the experimenters for high ($>50^{\circ}$) inclination is well founded. Inclinations between 40 and 50° might offer reasonable compromises for the Earth resources investigations; to overfly a variety of weather systems, however, constraint of the launch to northern hemisphere winter is required as well.

It is strongly urged that experiment inclination requirements be given high priority in mission planning for the Applications A package.


W.W. Elam

1011-WWE-b1

Attachment

Applications A Mission Orbital Inclination Requirements
Figures 1 & 2

Copy to

(see next page)

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Messrs.

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M. Savage - MLT
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J.H. Turnock - MA-4

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ORBITAL INCLINATION REQUIREMENTS FOR EXPERIMENTS

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EXPERIMENTS	PURPOSE	PI's ORBITAL INCLINATION PREFERENCE	REMARKS ON DESIRABLE ORBITAL INCLINATION
Day-Night Camera (Moody) S-039 (EJ-0513)	Night and day high resolution (0.6 n.m.) Cloud Images	No preference	28.5° orbit satisfactory to test instrument. More useful data from higher inclination orbit.
Dielectric Tape Camera (Arlaukaus) S-040 (EJ-0278)	High resolution (400 ft. from 200 n.m. altitude) image. Details of cloud formation associated with thunderstorms, tornadoes, squall lines etc.	No preference	28.5° orbit satisfactory to test instrument. More useful data from higher inclination orbit.
Millimeter Wave Propagation Experiment (Nichols) S-041 (EJ-0284)	Study atmospheric effects Polar Orbit effects on millimeter wave propagation		Effect of the atmosphere varies with latitude Orbital inclination $\geq 50^\circ$
Multispectral Photography (Colvocoreses) S-042 (EJ-0488)	Photograph Earth Resources test sites (30 m resolution) Obtain photography for Earth Resources applications already demonstrated	50°-55° Orbital Inclination	Primary test sites located in all latitudes in U.S., and in Labrador and Alaska, including sea ice and ice/water boundaries $>50^\circ$ orbital inclination - essential $>55^\circ$ orbital inclination desirable
Infrared Temperature Sounding (Shaw) S-043 (EJ-0274)	To determine temperature profile	Polar Orbit	Orbital inclination $\geq 50^\circ$

ORBITAL INCLINATION REQUIREMENTS FOR EXPERIMENTS (CONT'D)

(Page 2 of 4)

EXPERIMENTS	PURPOSE	PI's ORBITAL INCLINATION PREFERENCE	REMARKS ON DESIRABLE ORBITAL INCLINATION
Integrated Passive Microwave Experiments S-044 (EJ-0307)			
a. Microwave Spectral Measurements Near the 1.35 cm Water vapor resonance (Staelin) S-044A (EJ-0528)	Vertical water vapor profile. Sea state	60° Orbital Inclination	Marked variation of water vapor profile outside the tropics. Much greater range of sea states in high latitudes in winter $\geq 50^\circ$ orbital inclination
b. Atmospheric Temperature 12-75 km utilizing microwave emission from molecular oxygen (Lenoir) S-044B (EJ-0525)	Verticle temperature profile	60° orbital inclination	$\geq 50^\circ$ orbital inclination
c. Electrically Scanned microwave radiometer (Imager) (Thaddaeus) S-044 (EJ-0527)	Global study of Earth's surface and lower atmosphere at long wavelengths Map ice/water boundaries	60° orbital inclination	$\geq 60^\circ$ orbital inclination

ORBITAL INCLINATION REQUIREMENTS FOR EXPERIMENTS (CONT'D)

(Page 3 of 4)

EXPERIMENTS,	PURPOSE	PI'S ORBITAL INCLINATION PREFERENCE	REMARKS ON DESIRABLE ORBITAL INCLINATION
Near Infrared Filter Wedge spectrometer (Hovis) S-045 (EJ-0502)	Vertical distribution of water, ozone, CO ₂ ; effects of dust	High inclination orbit	Orbital inclination >50°
Measure Polarization of Radiation Emerging From the Top of the Atmosphere (Sekera) S-046 (EJ-0477)	Study effects of surface reflections. Vertical distribution of atmospheric aerosol.. Transmission (visible range) properties of the atmosphere.	High inclination orbit	Orbital inclination >50°
Measure Atmosphere Structure by Refraction Star Tracking Techniques (Fischbach) S-047 (EJ-0396)	Vertical atmospheric pressure profile	High inclination orbit	Parameter much more variable in high latitudes. Orbital inclination 60°
UHF Emissions From Cumulus Clouds (Rossby) S-048 (EJ-0526)	Detect strong convective weather phenomena	High inclination orbit	Orbital inclination >40°
High Resolution Infrared Spectroscopy (Hanel) S-049 (EJ-0511)	Vertical Profile of temperature, water vapor ozone, CH ₄ , N ₂ O	High inclination orbit	Orbital inclination >50°

ORBITAL INCLINATION REQUIREMENTS FOR EXPERIMENTS (CONT'D)
 (Page 4 of 4)

EXPERIMENTS	PURPOSE	PI'S ORBITAL INCLINATION PREFERENCE	REMARKS ON DESIRABLE ORBITAL INCLINATION
15 Micron Grating Spectrometer (Wark) S-050 (EJ-0515)	Vertical temperature profile	Polar Orbit	Orbital inclination $\geq 50^\circ$
Multi-Channel Radiometer (Rea) S-057 (EJ-0529)	High resolution maps of a. Particulate matter in atmosphere b. Vegetation c. Clouds	Polar Orbit	Orbital inclination $\geq 50^\circ$
Selective Chopper Radiometer (Houghton) S-060 (EJ-0640)	Vertical temperature profile	High inclination orbit	Orbital inclination $\geq 50^\circ$

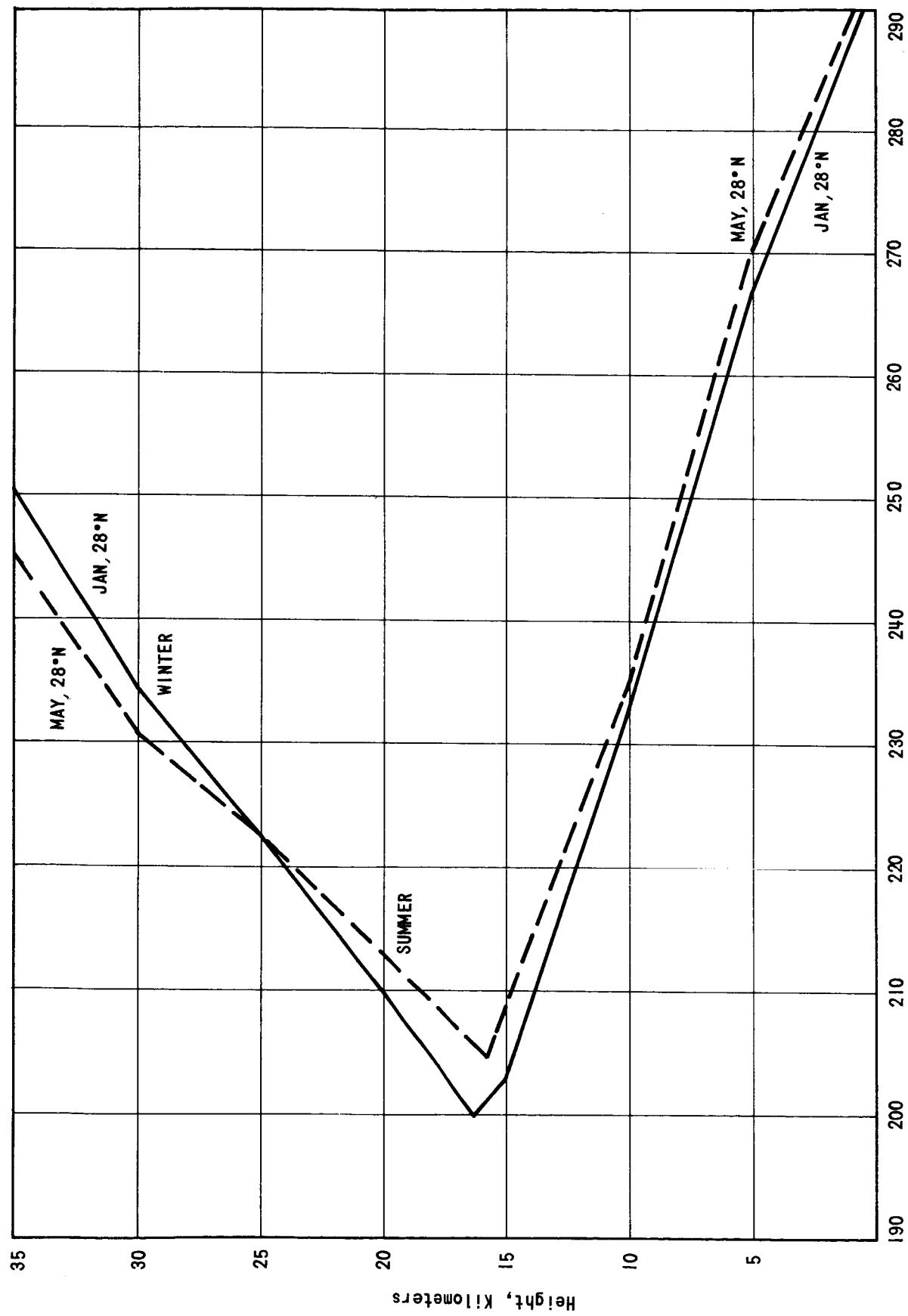


FIGURE I VERTICAL TEMPERATURE PROFILES AT CAPE KENNEDY
Temperature, Degrees Kelvin

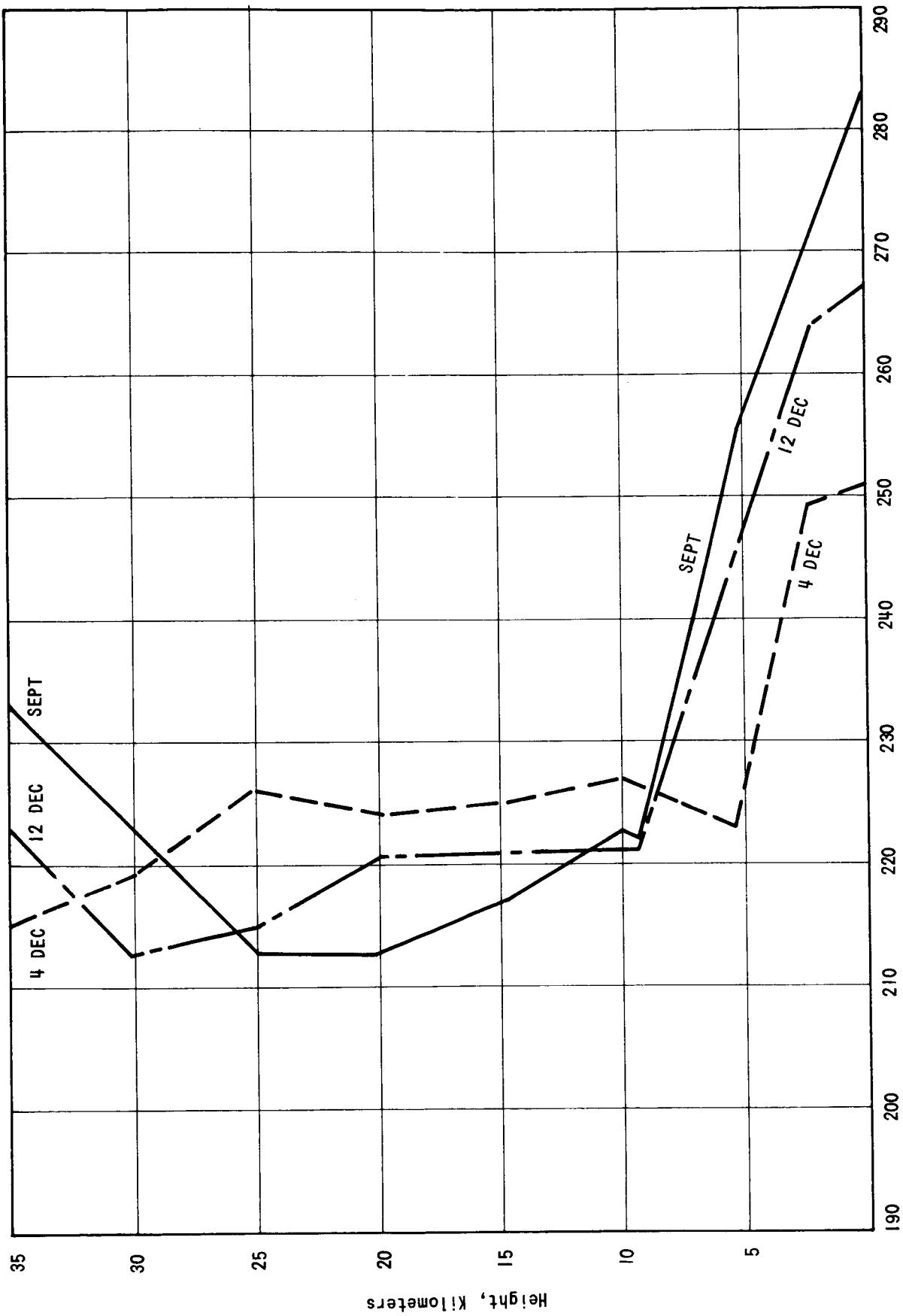


FIGURE 2 VERTICAL TEMPERATURE PROFILES AT 64° LATITUDE
Temperature, Degrees Kelvin